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This report provides a comparison of the environmental hazards from a release of elemental iodine (I_2) or methyl iodide (CH_3I). The data that was used for this comparison comes from the Health and Safety Division of Idaho Operations Office, U. S. Atomic Energy Commission, Controlled Environmental Radioiodine Tests (CERT). The areas of comparison are; relative deposition, transfer of iodine to milk, uptake by humans, and the relative hazards of CH_3I and I_2

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HUMAN RADIATION EXPERIMENTS

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THE COMPARATIVE ENVIRONMENTAL HAZARDS FROM A RELEASE OF METHYL IODIDE OR ELEMENTAL IODINE

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Abstract

Serious concern has been expressed over the behavior of methyl iodide and the effect of its behavior on possible environmental hazards from a release of radioiodine to the atmosphere. In an attempt to determine the fate of radioiodine in the environment, a series of planned releases is in progress at the National Reactor Testing Station, known as the Controlled Environmental Radioiodine Tests.

On the basis of 15 field releases and more than 40 laboratory experiments we have found there is no significant difference in the metabolism of methyl iodide (CH_3I) or elemental iodine (I_2) in cows or in humans. The only real factor of importance in assessing the consequences of a release is the difference in the deposition velocity of the two forms. The deposition velocity of CH_3I is about 0.05% that of I_2.

Evaluations of test data indicate that it is unlikely that the consequences from a release of mixtures of I_2 and CH_3I to the environment would be appreciably different from predictions based on the behavior of I_2 alone.

THE COMPARATIVE ENVIRONMENTAL HAZARDS FROM A RELEASE OF METHYL IODIDE OR ELEMENTAL IODINE

Much interest has been aroused in recent years over the possibility of methyl iodide being released as a result of a reactor accident. If CH_3I were released to a containment vessel, it seems likely that there would be a greater release of iodine to the environment than would be expected if only I_2 or other easily removed forms of iodine were present. It should be understood however, that a greater release, resulting from the presence of CH_3I, does not necessarily lead to significantly greater environmental hazards.

There are two primary modes of exposure to radioiodine in the environment; inhalation and consumption of contaminated milk In inhalation there are two points of concern in evaluating potential dose: the depletion of material in transport by turbulent deposition and the retention and metabolism of the inhaled material. In considering ingestion dose there are similar factors; again depletion must be considered in estimating the amount that is available for deposition at any downwind location, deposition determines the amount available to dairy cattle, transfer processes from grass to milk, and finally the retention and metabolism of the ingested radioiodine. Each of these factors, in addition to those relevant to iodine behavior in a containment vessel, must be evaluated before the comparative hazards of I_2 and CH_3I can be determined.

The Health and Safety Division of Idaho Operations Office, USAEC, is attempting to relate the environmental hazards from releases of various forms of radioiodine through a series of planned releases known as the CERT program (Controlled Environmental Radioiodine Tests)[1-3]. Since its inception, there have been 15 field tests and approximately 40 laboratory experiments. Of the field releases, three have been made with CH_3I, the rest with I_2. The CH_3I releases have included an 8 curie daytime release on July 21, 1966 and a 1 curie nighttime release on July 26, 1966. Although the program has not been concluded, we have a considerable body of data which, with results from other workers in the field, allow a reasonable comparison of the behavior of CH_3I and I_2.

1. Relative Deposition of CH_3I and I_2

   It appears that the difference in deposition of the two forms is the major factor in assessing environmental hazards. Tests conducted this year show that the deposition of CH_3I is on the order of 0.05%

rate of I_2, under similar conditions. For all practical purposes, CH_3I is a nondepositing tracer.

As a consequence, depletion by turbulent deposition becomes insignificant for this form of iodine. A recent study [4] indicated that the depletion factor for I_2 - the amount originally released divided by amount remaining airborne, under conditions normally assumed for major reactor accidents, (stable meteorological conditions, ground level release, total deposition velocity 0.84 cm/sec) was about 2.7 at a distance of 10^4 meters. Thus, for a given release under these conditions, one would expect doses to be a factor of 2.7 greater for CH_3I than for I_2, since there would be no activity loss by depletion. The difference in deposition greatly reduces the net ingestion potential of CH_3I, since pasture contamination from CH_3I will be only 0.05% that from I_2.

2. Transfer of Iodine to Milk

Efforts have been made to measure and/or account for the movement of iodine from its point of consumption by cows to its secretion in milk. This type of study has been an integral part of the CERT program; cows have been grazed on pasture during several of the tests and a number of "spike" studies have been attempted. Thus far, we have observed no significant difference in the uptake and retention between CH_3I and I_2. Normal values of iodine secretion in each liter of milk range from 0.5 to 2.0% of the activity consumed with forage each day.

Inhalation of iodine by the cow is another way for iodine to enter milk. For I_2, this mode of uptake is insignificant compared to that from ingestion. This is not the case with CH_3I; results from the July 21, 1966 test showed that a time integrated air concentration of 1 C_i - sec/m^3 would lead to a peak concentration on the order of 10^{-5} C_i/liter and to an integrated milk activity of about 2 x 10^{-5} C_i-day/liter from inhalation alone. This is roughly the same milk activity resulting from ingestion of contaminated grass. Unlike the milk activity from ingestion (which reaches a peak within 50 hours), the milk activity from inhalation appears at the next milking or within 4 hours after the exposure.

3. Uptake by Humans

Although there have been a large number of uptake studies of iodine for clinical purposes, there is little information on the uptake of inhaled iodine. Recent CERT inhalation studies have shown interesting differences in the behavior of the two forms of iodine with respect to human uptake. These differences appear to be closely related to the changing characteristics of the material with distance.

Attempts have been made to determine the physical properties of airborne radioiodine as a function of distance from the source. These studies have shown that I_2 undergoes a rapid interaction with naturally occurring aerosols. This is shown by air samples collected at various distances from the source: for I_2, less than 1 per cent of the collected

activity is found on particulate filters within a few meters of the source while about 50% is found on particulate for distances greater than 100 meters from the source. There is, however, no apparent change with distance with CH_3I; essentially all activity passes through the particulate filters.

This corresponds to data on changes in body retention for individuals exposed at various distances from a release. With both I_2 and CH_3I, individuals exposed to radioiodine close to the release point showed no appreciable skin contamination or residual contamination in the nasopharynx or lung. The retention curves as determined by "in vivo" counting are identical to curves derived from clinical studies 5/. The same is true for CH_3I exposures at distances removed from the source. On the other hand, exposure to radioiodine at greater distances, released as I_2, results in considerable surface contamination and/or deposition in the lung and nasopharynx. Our recent studies show skin contamination, (most of which was removed by showering within a few hours after exposure) on the order of 2-4 times that which is internally retained by inhalation. There was, however, no indication, that this results in greater thyroid uptake than would be expected from inhalation alone.

4. Relative Hazards of CH_3I and I_2

From the results of the Controlled Environmental Radioiodine Tests briefly summarized above, it is clear that the differences in the behavior of CH_3I and I_2 may lead to marked differences in dose from inhalation or ingestion. In those areas where there are no dairy cattle, inhalation of both CH_3I and I_2 becomes controlling. In this case, the dose from methyl iodide is at least a factor of three times that from I_2 - this is primarily due to differences in depletion of iodine by deposition to the point of interest.

Where there are dairy cattle near a release point, the dose from ingestion of contaminated milk may be as much as a factor of 1000 times 3/ greater than from inhalation - if I_2 is the major constitutent of the release. For CH_3I, it is exceedingly improbable that the ingestion hazard would ever approach that from inhalation Thus, two points must be considered in evaluating potential dose from CH_3I or I_2. The initial impact of a release (i.e. - inhalation) will most certainly be greater for CH_3I than I_2. The longer term hazards are, on the other hand, much greater for I_2. Using the results from reference 4 and the techniques described in reference 3, I have attempted to show the net hazard from different combinations of I_2 and CH_3I under typical adverse meteorological conditions. As can be seen in Figure 1 the dose from inhalation becomes controlling at about 95% methyl iodide. The inhalation dose is about twice that for I_2 when the release is a combination of about 50% CH_3I - 50% I_2. The ingestion dose has been estimated on the basis of two days exposure, since it is probable that protective actions would be initiated within this time to preclude further ingestion of contaminated milk.

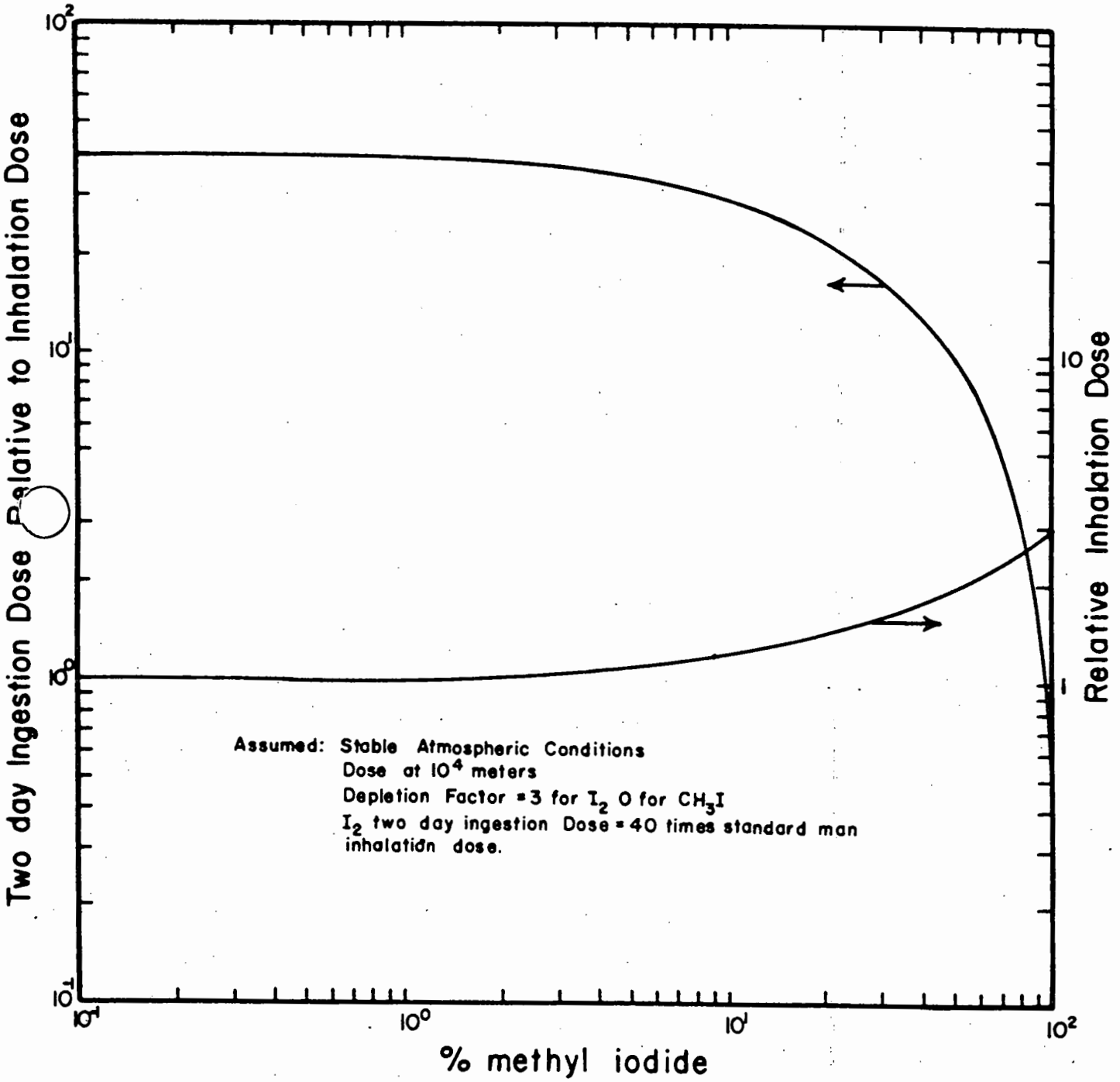

Figure 1 Ingestion and Inhalation Dose for Various Mixtures of $CH_3{}^{131}I$ and $^{131}I_2$